Montana Department of
ENVIRONMENTAL QUALITY

MEMO

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From: Michael Suplee, Ph.D., Water Quality Standards Section

Date: 8/6/2015

RE: Recommendations for Nutrient and Related Targets for Streams in the Flathead River Basin

In accordance with the TMDL Teaming Agreement for the Flathead Basin Nutrient TMDLs and Modeling, DEQ is responsible for the establishment of TMDL targets for the Flathead Basin TMDLs and interpretation of the applicable water quality standards in the context of TMDL development in the Flathead Basin. The purpose of this memorandum is to provide the Flathead Basin TMDL Team with guidance regarding nutrient targets for wadable streams in the Flathead Basin.

The Standards Section has outlined its overall approach for deriving numeric nutrient criteria and protecting beneficial uses in a peer-review technical document (Suplee *et al.*, 2008), available on the World Wide Web at: http://www.deq.state.mt.us/wqinfo/Standards/NumericNutrientCriteria.asp. The purpose of this memo is to outline recommendations specific to the Flathead Basin.

DEQ is using Omernik ecoregions (level III and IV)(Woods *et al*., 2002) to segregate nutrient criteria zones. At this time, only level-III recommendations are available for this watershed. The Flathead Basin contains parts of two level III ecoregions: the Northern Rockies (No. 15) and the Canadian Rockies (No. 41). It appears that all of the listed streams are within the Northern Rockies except for Challenge Creek, which is in the Canadian Rockies. The nutrient criteria and benthic algae recommendations for these two ecoregions are shown in Table 1below, per recommendations in Suplee *et al*. (2008). Analyses completed since Suplee *et al.* (2008) was released further support these recommendations, although the most recent analyses indicate that the Canadian Rockies TP criteria can be raised somewhat (to 0.011 mg TP/L, 0.227 mg TN/L, and 0.062 mg NO_{2+3}/L) based on additional stressor-response work carried out in the Canadian Rockies. All other aspects of the criteria (period of application, algae levels) remain the same. If a downstream lake is involved, year round loading considerations to the lake will likely apply, and may alter the concentration limits shown. However, this memo only addresses criteria for stream protection. Also note that these are not final criteria; final criteria will be released in a DEQ circular, possibly later this year.

Table 1. Numeric nutrient and benthic algae criteria recommendations, as of November 2008.

Level III Ecoregion	Period When Criteria Apply	Nutrient Criteria: Reference Percentile Criteria Are Linked to	TP (mg/L)	TN (mg/L)	NO_{2+3} (mg/L)	Benthic Algae Criteria
Northern Rockies	July 1 -Sept. 30	90^{th}	0.012	0.233	0.081	150 mg Chl *a* /m^2 (36 g AFDW/m^2)
Canadian Rockies	July 1 -Sept. 30	90^{th}	0.006	0.209	0.020	150 mg Chl *a* /m^2 (36 g AFDW/m^2)

I recommend that 12 independent samples for each nutrient of concern be collected within each stream segment in question. The nutrient samples should be temporally and spatially independent. Same-site sampling events should be separated by approximately one month to assure temporal independence. Spatial independence is more problematic, but it is suggested that you follow these guidelines:

- Sites (or very short reaches equivalent to sites) should be located a minimum of 1 mile apart along the stream segment.
- Sites may be placed < 1 mile apart on the stream segment **if** there is a active tributary confluencing with the segment between the two sites.
- Land use changes and land form changes should be considered and can be used to help ID additional sampling sites within the stream reach. See page 11-12 of DEQ (2005).

Detailed recommendations concerning sampling design are provided in Appendix H of Varghese *et al.* (2008), "2008-Updated Statistical Analyses of Water Quality Data…" available at the website above.

Analysis indicates that a 20% exceedence of the nutrient criteria (but *not* the algae biomass criteria) can occur without impacting beneficial uses (Varghese *et al*., 2008); thus, a 20% allowable exceedence rate is incorporated into statistical testing procedures (more on this in a moment).

Benthic algae data should be collected at sites following DEQ SOPs (DEQ, 2008). However, twelve algae sampling events need not be undertaken; a single sampling event at each site is sufficient, although if time and money allow multiple sampling events are better. I recommend that both Chl *a* and AFDW be measured, as benthic algae have different growth phases, some phases being characterized by fairly low Chl *a*: AFDW ratios. Measuring both Chl *a* and AFDW will assure that compliance can be checked against either biomass criterion. Each sampling event should be viewed on its own merits (i.e., do not average algae data across sites, or across time at a single site).

The nutrient data can be evaluated using two different statistical testing procedures. Since all of these streams are currently 303(d)-listed, the two tests to be used are found in an Excel file named "MT-ComplianceTool.xls", available from DEQ. The conditions for the first test (Exact Binomial Test) should be set such that alpha = 0.25, critical exceedence rate = 0.2 (20%, as discussed above), and the effect size set at 0.15. (I can assist with the use of these tools when they are used for the first time.) The other test, the One Sample Student's t-test for the Mean, should have an alpha = 0.25, and you will also need to enter the nutrient criterion concentration and also the data you have collected from the stream segment. Historic data can also be included in these tests; presumably you will want to use data 5-10 years old or newer.

The results from the two statistical tests, along with the results from the benthic algae sampling, are then considered together in a decision matrix (Table 2, below). In general, more emphasis is placed on the results from the Exact Binomial Test and the algae sampling than on the T-test. Some of the eight scenarios shown may be unlikely to arise, but all permutations are being presented at this point, until DEQ has more experience with using this decision matrix. Stream segments for which the decision is "Not in Compliance" can be considered to be exceeding the nutrient criteria.

Again, remember that these numeric recommendations are not BER-approved water quality standards, although it is likely that DEQ will approach the BER with numeric nutrient criteria in 2009. They are the best available scientific and technical recommendations the DEQ can currently offer as a direct interpretation of the narrative water quality standard found at ARM 17.30.637(1)(e).

Much more detail on the statistical tools, exceedence rate, sampling design, assumptions, etc. can be found in Appendix H of Varghese *et al.* (2008) at the website provided above. Please do not hesitate to contact me with any questions you may have at (406) 444-0831, or msuplee@mt.gov.

Table 2. Decision rules for determining compliance with nutrient criteria, cold-water streams. For each statistical test, regardless of the form of the null hypothesis, PASS means the stream segment complies with the nutrient criterion, FAIL means the stream segment does not comply with the nutrient criterion.

Scenario	Binomial Test	T-test	Benthic Algae*	**Resulting Decision**	Notes on Decision
1	PASS	PASS	≤150 mg Chl*a* /m^2 or ≤36 g AFDW/m^2	In Compliance	All indications show that the stream is in compliance.
2	PASS	FAIL	≤150 mg Chl*a* /m^2 or ≤36 g AFDW/m^2	In Compliance	Suggests pulsed nutrient loads occur but are not resulting in elevated benthic algae biomass.
3	FAIL	PASS	≤150 mg Chl*a* /m^2 or ≤36 g AFDW/m^2	Borderline	Likely that segment sometimes has high benthic algae biomass, but the timing of the algae sampling may have missed high levels. Borderline case; compliance or non-compliance may be equally justifiable; use other accompanying data (e.g., biometrics) to confirm decision. OR, further sample algae & nutrients.
4	FAIL	FAIL	≤150 mg Chl*a* /m^2 or ≤36 g AFDW/m^2	Not in Compliance	Likely that segment has high benthic algae biomass, but the timing of the algae sampling may have missed the high levels. **Further algae sampling may be justified.**
5	PASS	PASS	≥150 mg Chl*a* /m^2 or ≥36 g AFDW/m^2	Not in Compliance	Algae may be taking up nutrients and leading to low instream nutrient concentrations with concurrent high benthic algae biomass.
6	PASS	FAIL	≥150 mg Chl*a* /m^2 or ≥36 g AFDW/m^2	Not in Compliance	Non-compliance with the T-test suggests that pulsed nutrient loads are allowing high algae biomass to be maintained via luxury uptake.
7	FAIL	PASS	≥150 mg Chl*a* /m^2 or ≥36 g AFDW/m^2	Not in Compliance	Suggests sustained nutrient values near the standard but not necessarily pulsed nutrient loading.
8	FAIL	FAIL	≥150 mg Chl*a* /m^2 or ≥36 g AFDW/m^2	Not in Compliance	All indicators show that the stream is not in compliance.

* Benthic algae biomass collected and summarized as per DEQ SOPs, for a single site (short reach), during any given sampling event. Unlike nutrient samples, *do not* average together algae biomass results from different sites (short reaches) across the stream segment. Consider each site (short reach) on its own merits.

REFERENCE LIST

DEQ (Montana Department of Environmental Quality), 2005. Field Procedures Manual for Water Quality Assessment Monitoring. Water Quality Planning Bureau, Document No. WQPBWQM-020, Revision 2. April 21, 2005.

DEQ (Montana Department of Environmental Quality), 2008. Sample Collection and Laboratory Analysis of Chlorophyll-a, Standard Operating Procedure. Water Quality Planning Bureau, Document No. WQPBWQM-011, Revision 4, June 5, 2008.

Suplee, M., V. Watson, A. Varghese, and J. Cleland, 2008. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers. Montana Department of Environmental Quality, Water Quality Planning Bureau, November 2008.

Varghese, A., J. Cleland, and B. Dederick, 2008. Updated Statistical Analyses of Water Quality Data, Compliance Tools, and Changepoint Assessment for Montana Rivers and Streams. Prepared for DEQ by ICF International, June 27, 2008.

Woods, A.J., J.M. Omernik, J.A. Nesser, J. Shelden, J.A. Comstock, and S. J. Azevedo, 2002. Ecoregions of Montana, 2nd edition. (Color Poster with Map, Descriptive Text, Summary Tables, and Photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000).